New Results from FLASHFlux: A Case Study of the Observed Radiative Anomalies In the Arctic for 2007 and 2008 Summer Seasons

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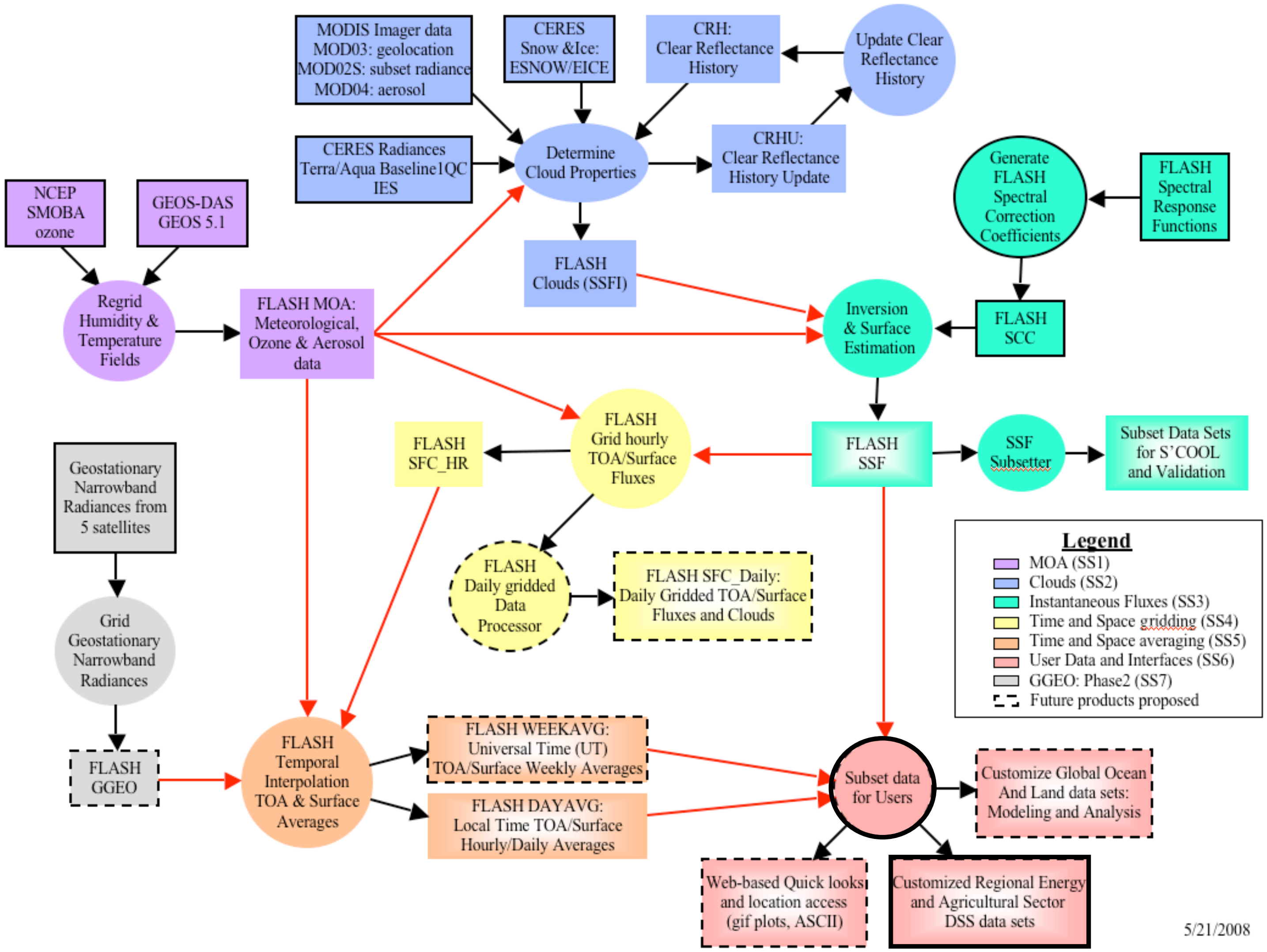
I. Introduction

The Fast Longwave And SHortwave Radiative Fluxes (FLASHFlux) project was initiated at the NASA Langley Research Center to meet the needs of the science community for global near real-time surface and top-of-atmosphere (TOA) radiative fluxes. This was accomplished by speeding the processing of the Clouds and Earth Radiance Energy System (CERES) processing system using simplified calibration and averaging procedures and the CERES fast radiation algorithms to produce the fluxes within a week of real-time (see Figure 1).

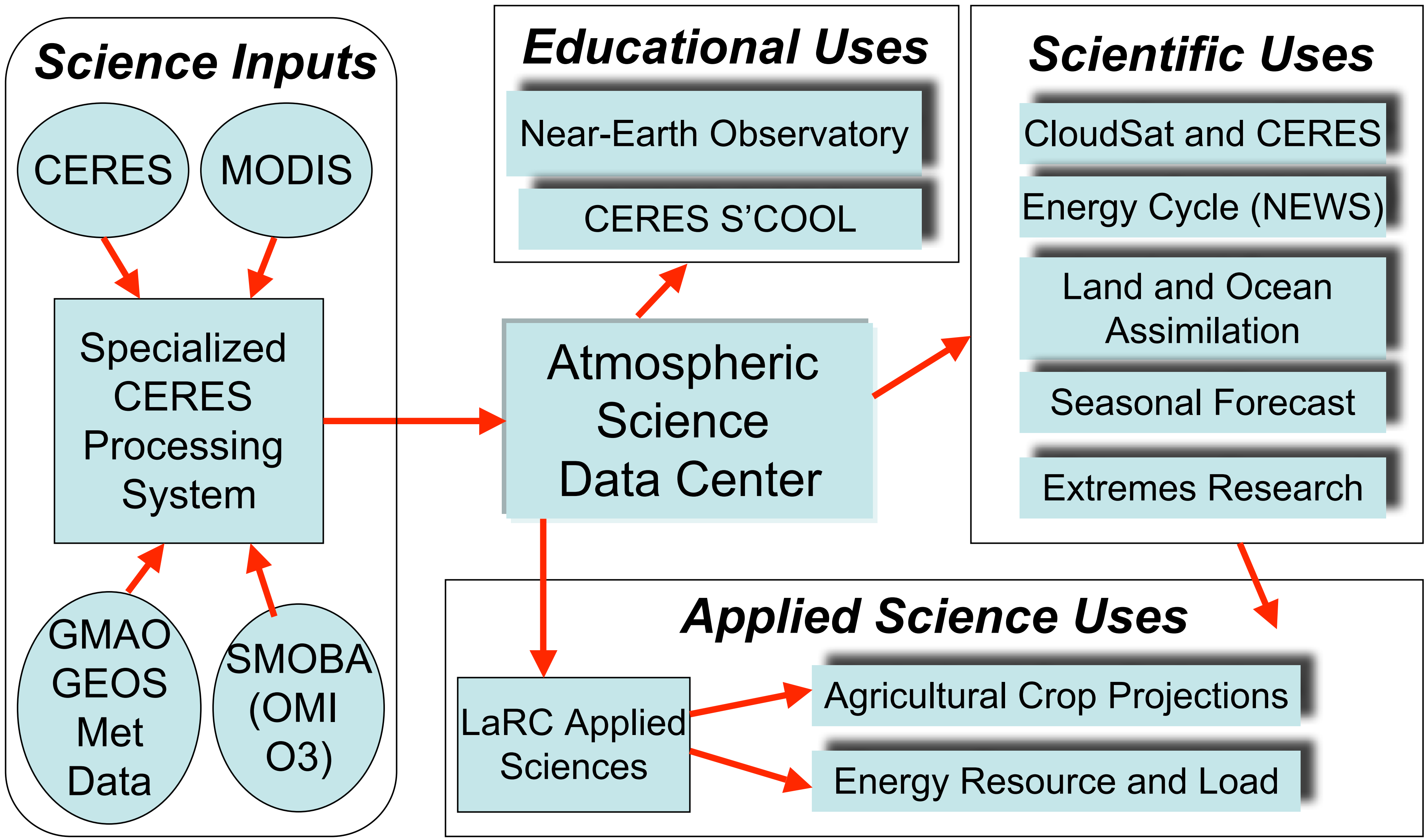
Figure 1: FLASHFlux Data Flow



* FLASHFlux provides near real-time quantification of TOA and surface radiative fluxes. Timely analysis of these fluxes also helps to characterize their spatial and temporal variability on regional and global scales. Daily averaged products provide important insight into the understanding of the relationships between weather and climate processes.

* FLASHFlux project has developed software and protocols necessary for disseminating near real-time estimates of shortwave (solar) and longwave (terrestrial) flux products to climate and ocean modelers, satellite science teams, and renewable energy and agricultural industries Figure 2 shows the various users for FLASHFlux data products.

Figure 2: FLASHFLUX: Schematic Mapping to Realized and Potential Uses



* FLASHFlux data products include overpass CERES pixel level products (consistent with CERES Single Scanner Footprint - SSF) available within 5-6 days of real-time. Hourly/daily averaged are available within 6-7 days during operational processing.

* FLASHFlux data products are available at the NASA Langley Atmospheric Data Center (eosweb.larc.nasa.gov/PRODOCS/flashflux/table_flashflux.html) and more general information is available at the FLASHFlux web site flashflux.larc.nasa.gov.

In this poster, we first show validation results of FLASHFlux TOA and surface fluxes compared to surface site measurements. Then FLASHFlux data products are averaged for the Arctic summers (June-July-August) of 2007 and 2008. These are contrasted to the CERES averaged summers from 2000-2004 for TOA and for surface LW.

II. Overpass (SSF) Resolution Validation

FLASHFlux produces overpass data products (SSF) for TOA by inverting CERES radiances and surface fluxes using updated versions of the CERES Surface-Only Flux Algorithms (SOFA) (Gupta *et al*., 2004, Kratz *et al*., 2009). MODIS cloud properties and Goddard Earth Observing System operational analyses are used for inputs. The resolution is the CERES footprint size of 20 km at nadir. Figure 3 shows composite of all the daytime Aqua overpasses for TOA and surface fluxes on December 27, 2008.

FLASHflux SSF surface fluxes are compared to measurements from the SURFRAD network for validation. Only fluxes from footprints within 10 km of the site are used. The LW and SW fluxes are then compared to the 1-minute averaged LW and 60 minute averaged SW surface measurements respectively. Figure 4 compares FLASHFlux to surface measurement for overpasses spanning from 4/1/2007 to 3/31/2008.

Figure 3: Daytime Only Composite Overpass Fluxes from FLASHFlux (CERES) Footprint Resolution Data Products for Dec 27, 2008.

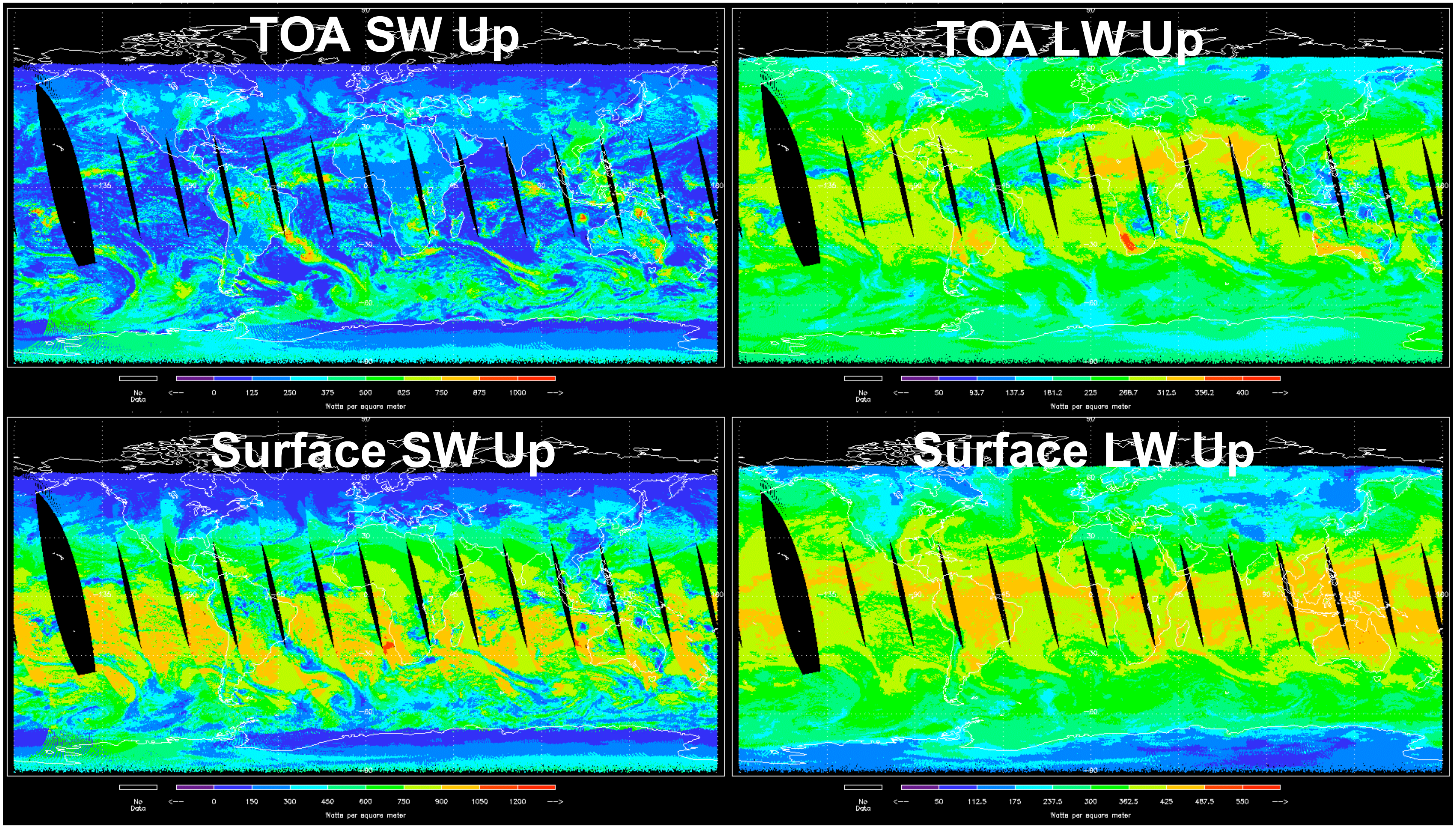
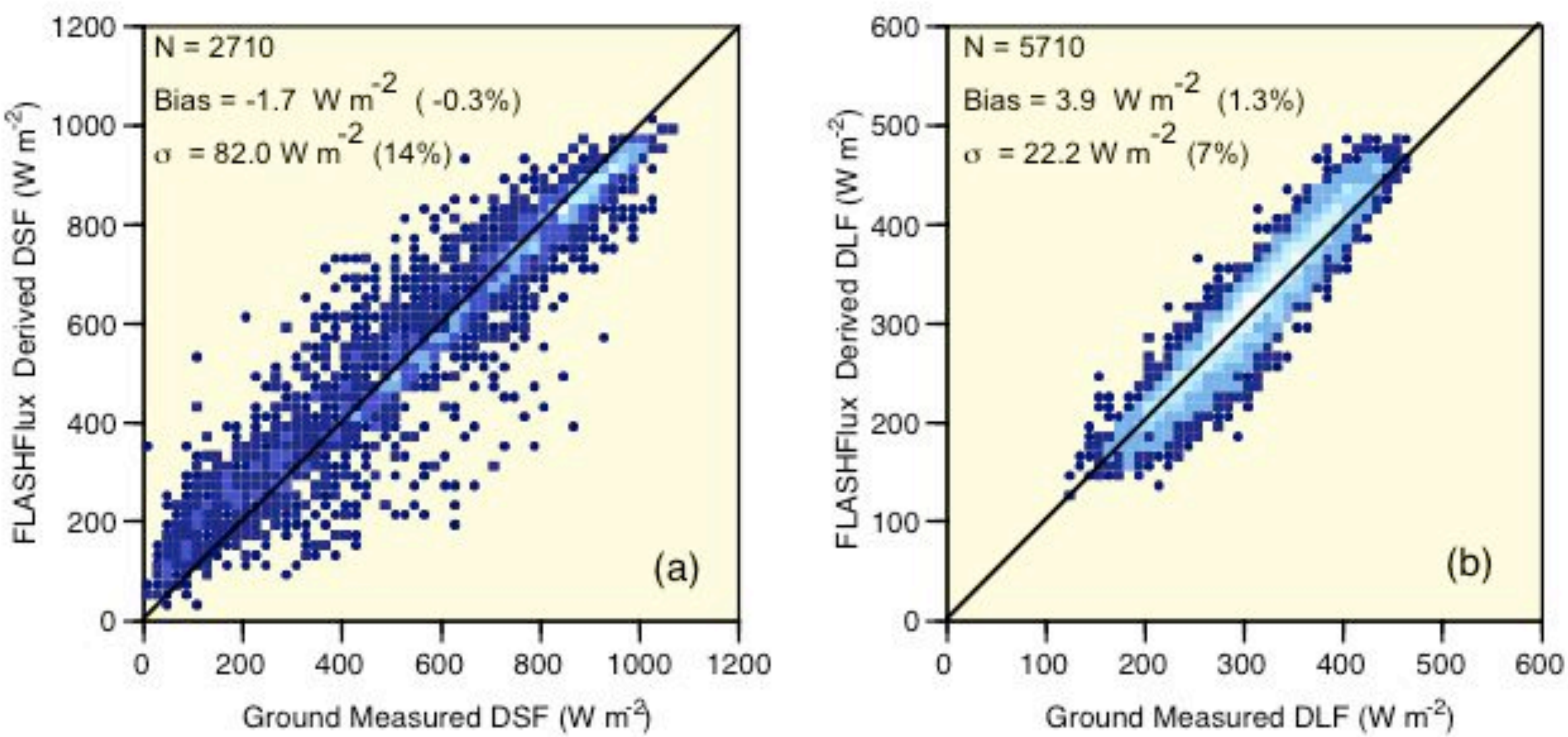


Figure 4: FLASHFlux Overpass (SSF) Surface Flux Validation

Instantaneous surface validation against SURFRAD measurements from April 2007 - March 2008



III. Daily Averaged Resolution Validation

FLASHFlux produces spatially averages MODIS derived cloud and surface using the CERES algorithms to a resolution base of 1^{o}x1^{o} for measurements from both Terra and Aqua. These properties are interpolated in time using all available measurements on an hourly basis and the FLASHFlux modified CERES Surface-only Flux algorithms are processed. Figure 5 shows daily averaged TOA and Surface SW and LW fluxes for December 27, 2008.

The validation of the hourly/daily FLASHFlux data products is also completed using hourly/daily averaged SURFRAD measurements. Figure 6 shows the comparisons of daily averaged fluxes for all sites for same time period as Figure 4. Figure 7 shows a time series comparison between FLASHFlux and the Penn State site. The high correlation is noted.

Figure 5: FLASHFlux Daily Averaged TOA and Surface SW and LW fluxes for December 27, 2008

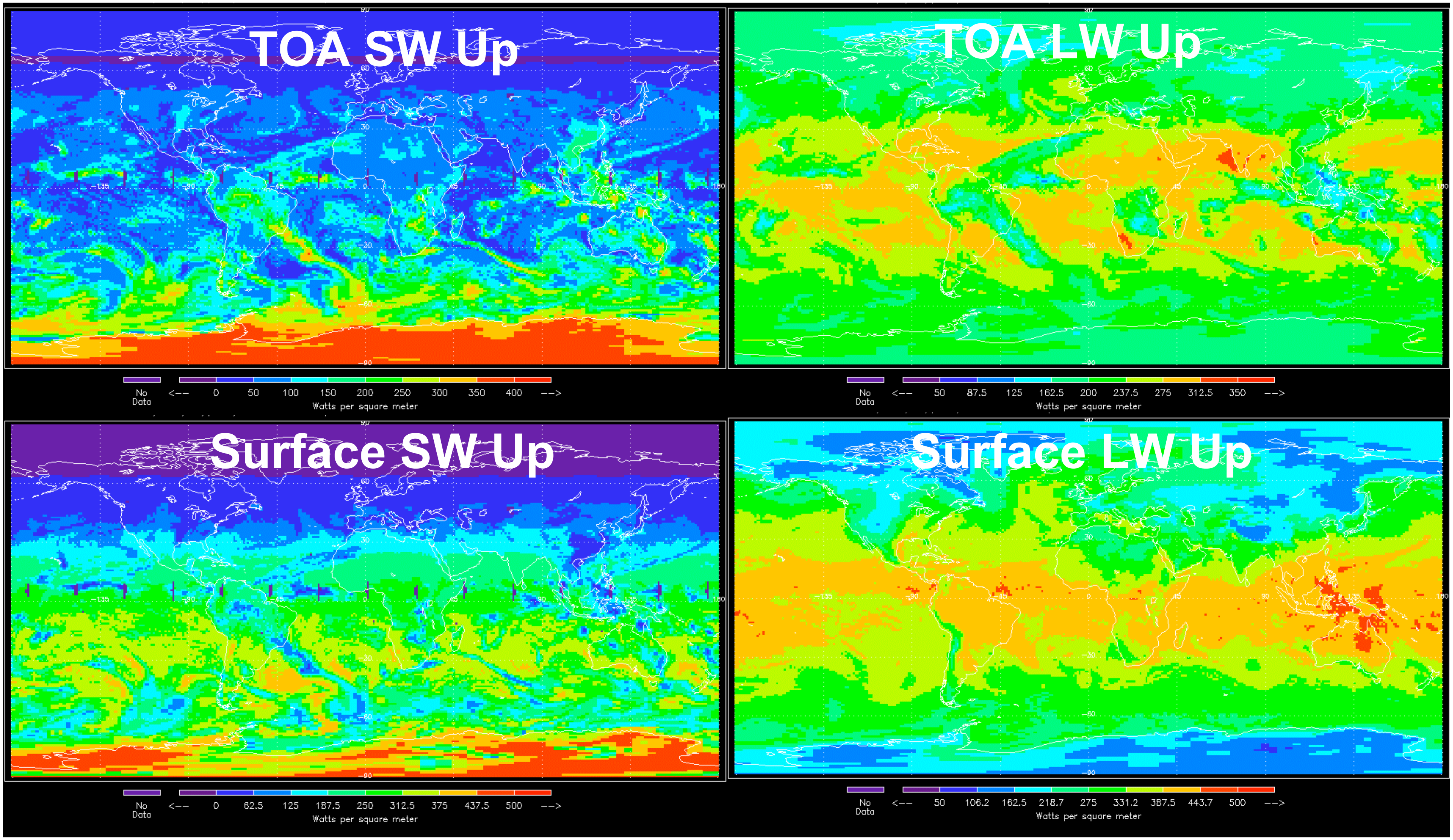


Figure 6: Daily averaged FLASHFlux derived fluxes compared to SURFRad Measurements.

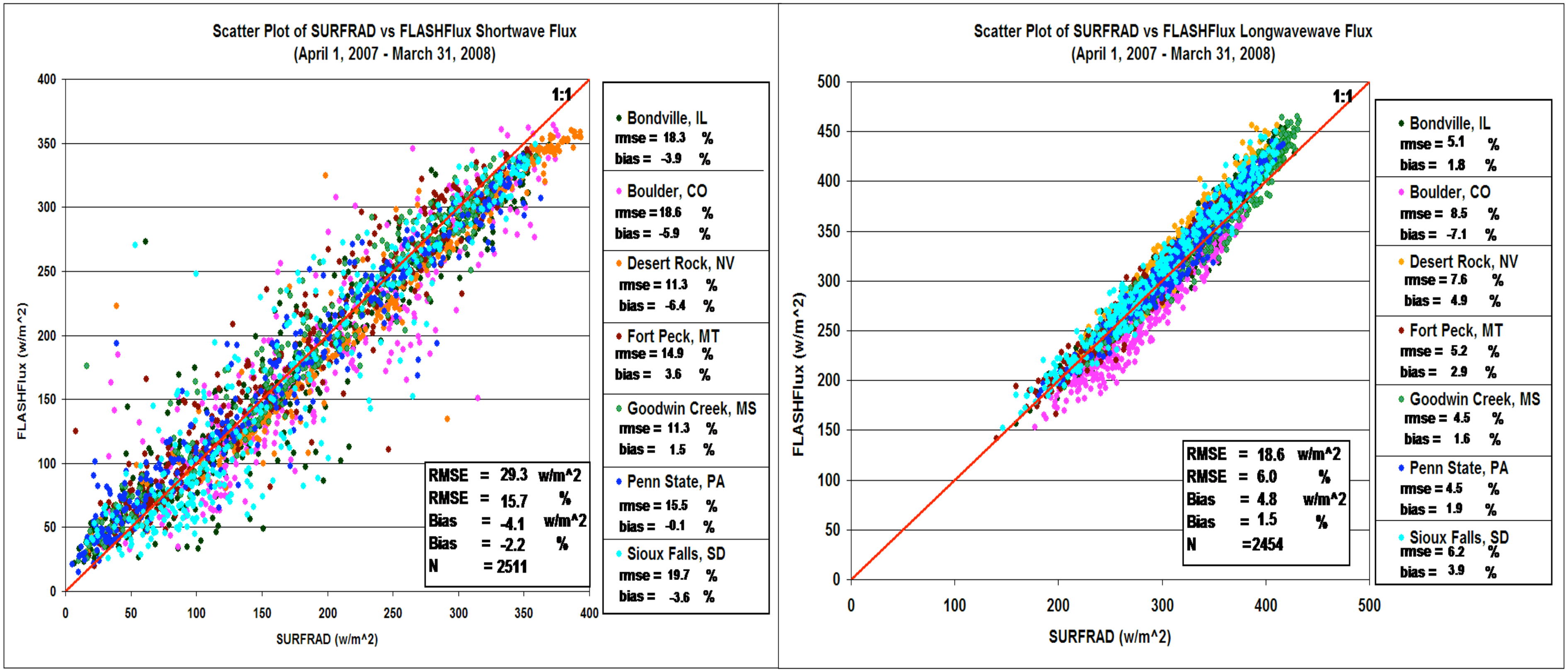
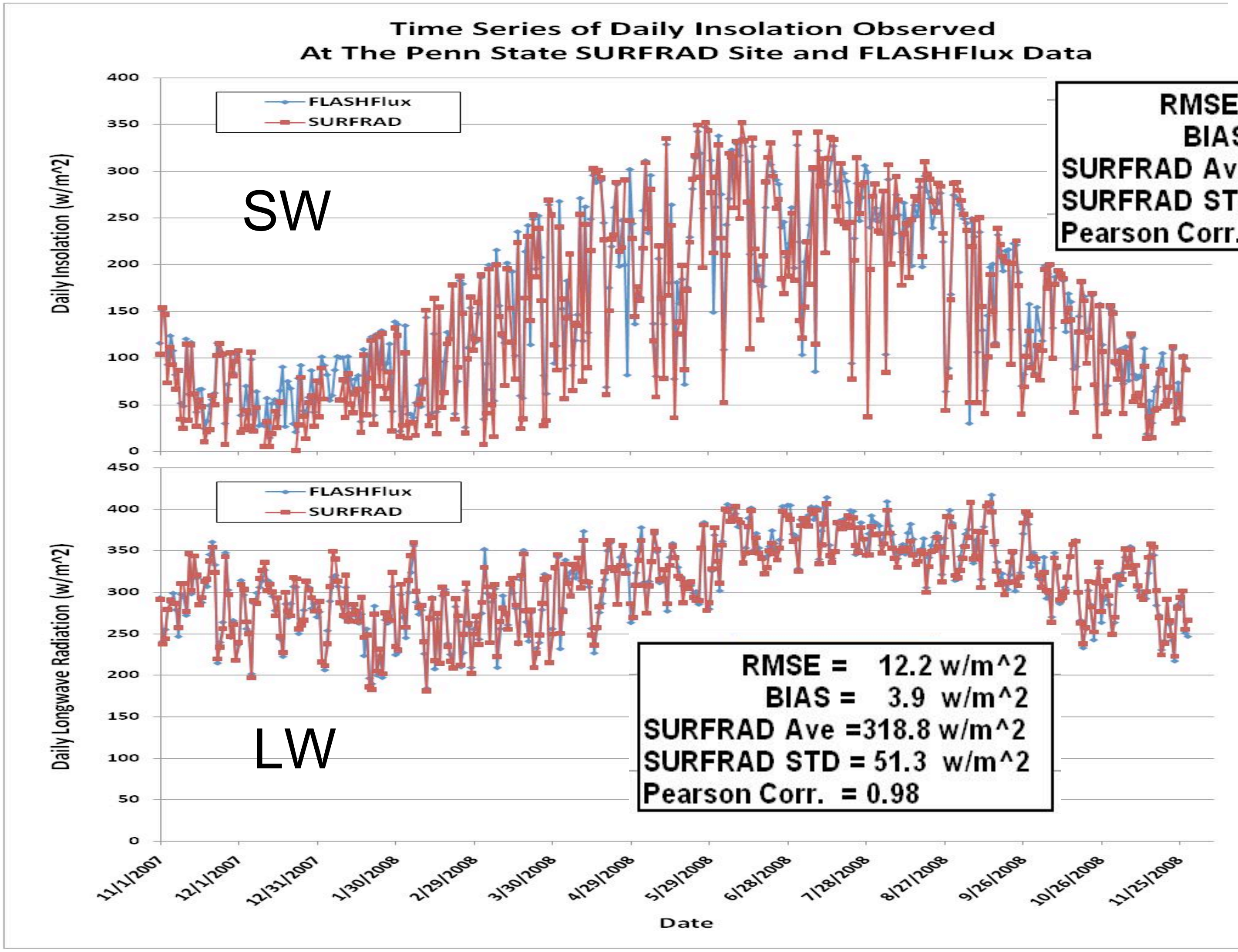


Figure 7a: Daily Averaged FLASHFLUX Time Series Comparisons for SW and LW



Flux Time Series Compared to the Penn State SURFRad site with statistics.

IV. Establishing a Baseline from CERES

CERES has released the SRBAVG version 2 monthly averaged fluxes from March 2000 through October 2005. Here, we use the JJA average for 5 of those years from 2000 to 2004 to establish climatology for the Arctic summer building from Kato et al (2007). FLASHFlux products are similar to the CERES SRBAVG in terms of base inversion and flux algorithms, but there are clear differences. These will be noted where appropriate. *Also we find that oddities in the CERES SRBAVG ice coverage and SW Arctic fluxes and the assumption of a climatological surface albedo in FLASHFlux will prevent meaningful analysis of the SW fluxes at this time. Therefore, we limit the remaining of the poster to analysis of the TOA fluxes and to the LW surface fluxes.*

Figure 8a-c shows the cloud, skin temperature and precipitable water meteorological 5-year means.
Figure 9a-d shows the results TOA SW and LW fluxes resulting from an inversion of the CERES radiances.
Figure 10a-b shows the results Surface LW fluxes resulting in part from the inputs in figure 8.

Figure 8a-c: JJA Averaged Cloud Fraction, Skin Temperature and Precipitable Fields for 2000-2004.

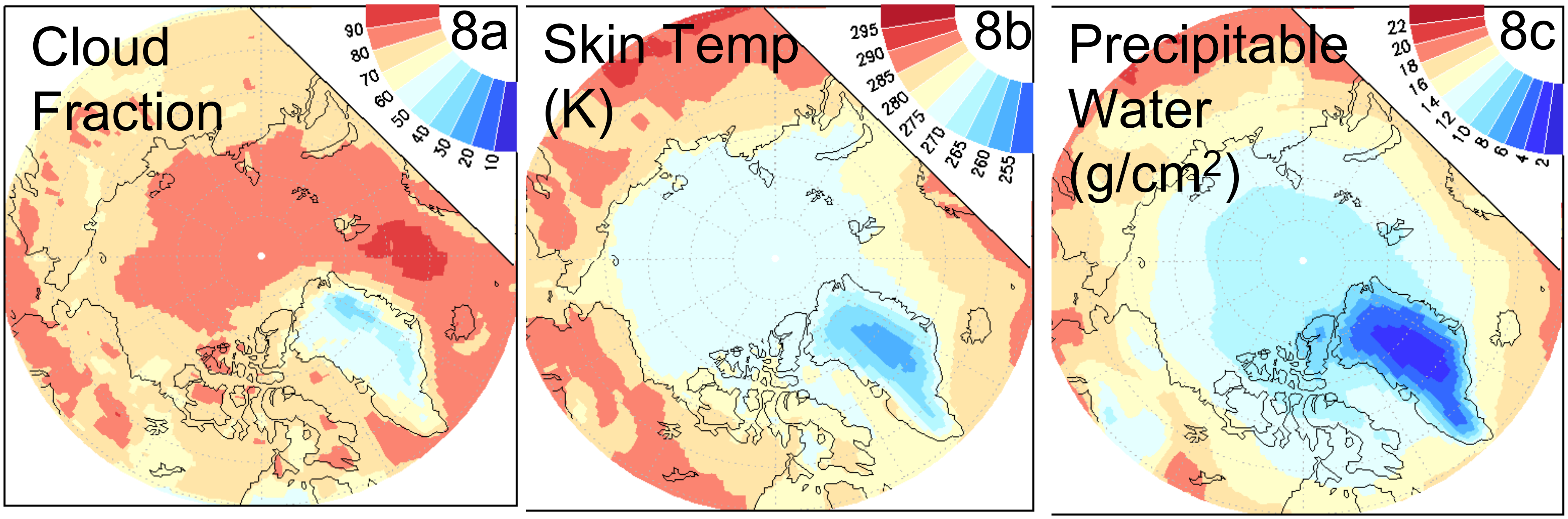
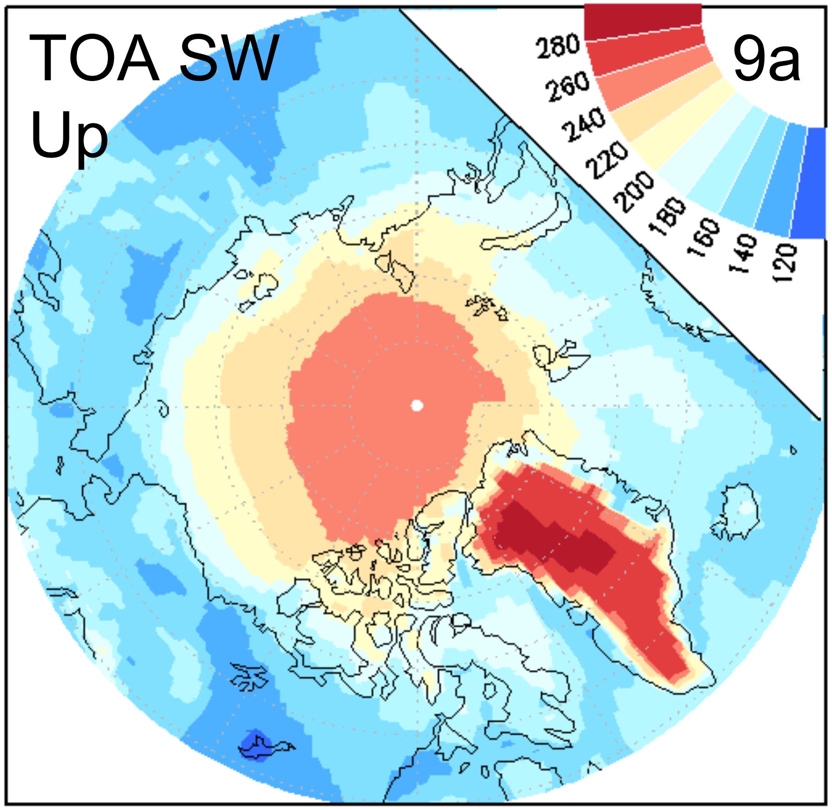
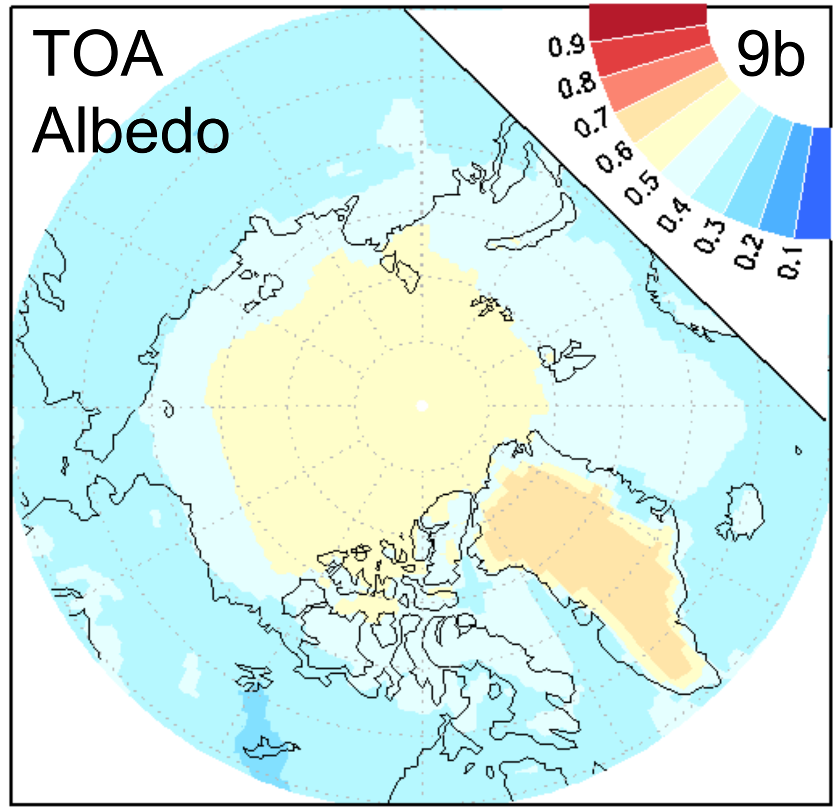


Figure 9a-d: JJA Averaged TOA Fluxes for 2000-2004.





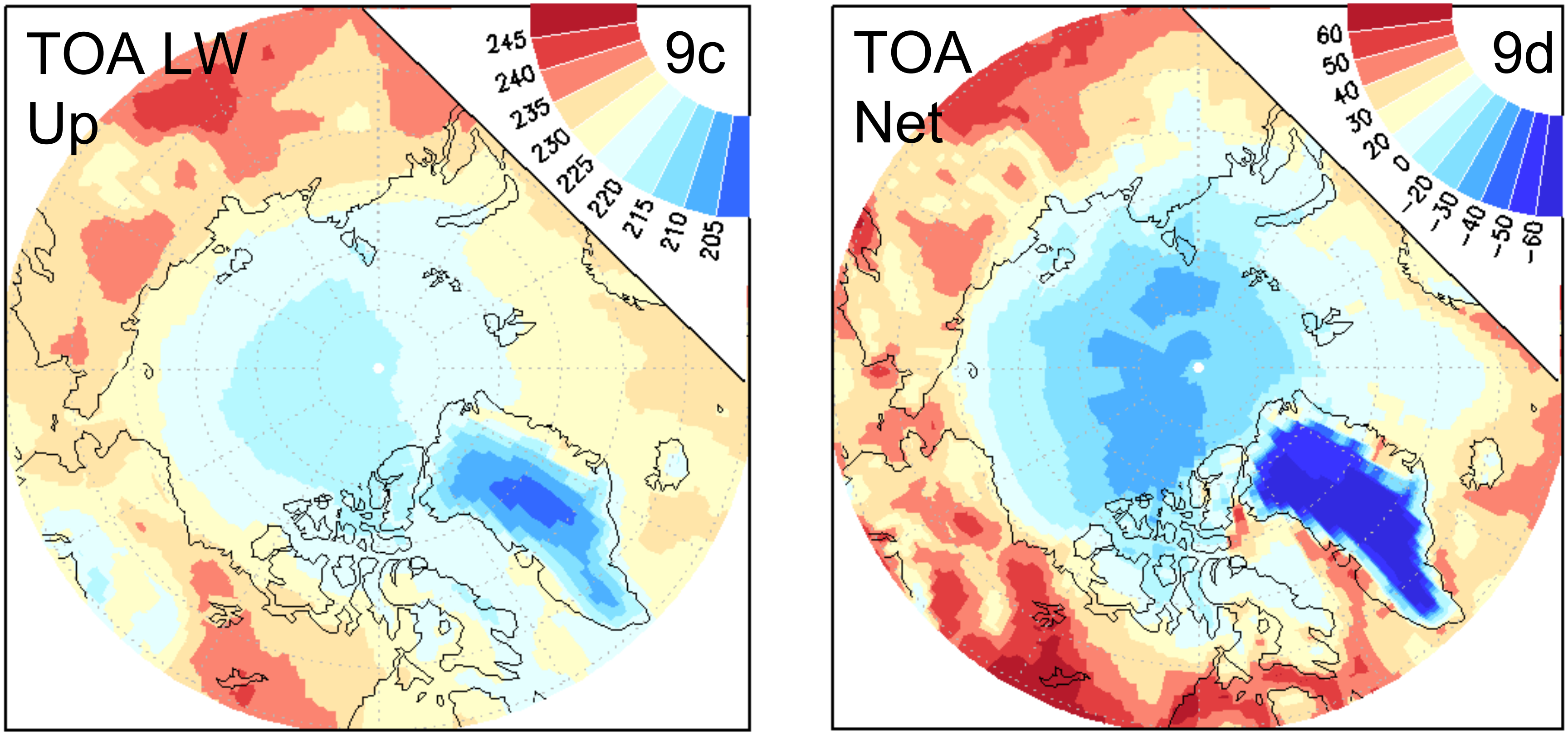
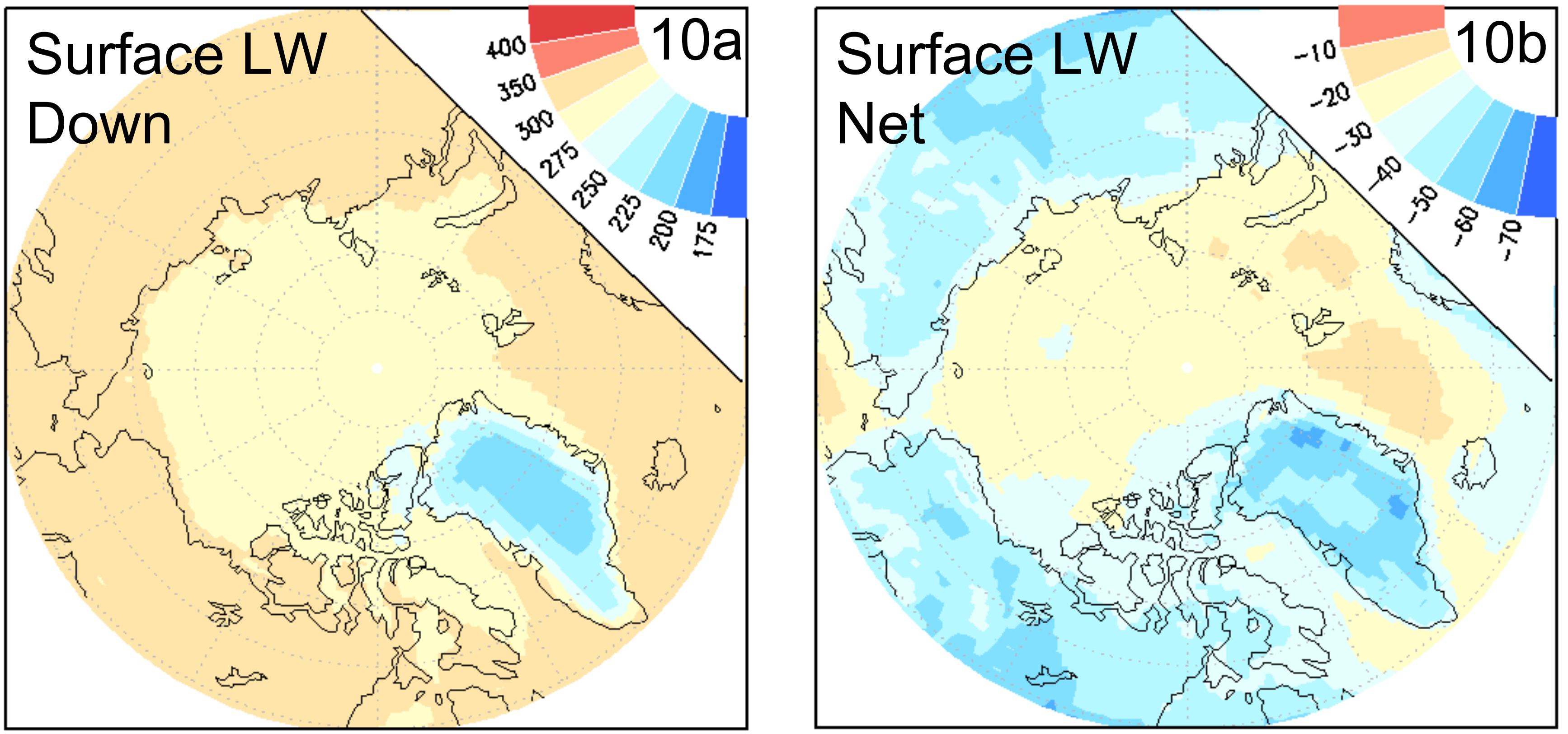

TOA LW Up
9c
245
240
235
230
225
220
215
210
205
TOA Net
9d
60
50
40
30
20
0
-20
-30
-40
-50
-60

Figure 10a-b: JJA Averaged surface LW down and LW net surface Fluxes for 2000-2004.



V. Evaluating 2007 Anomalies

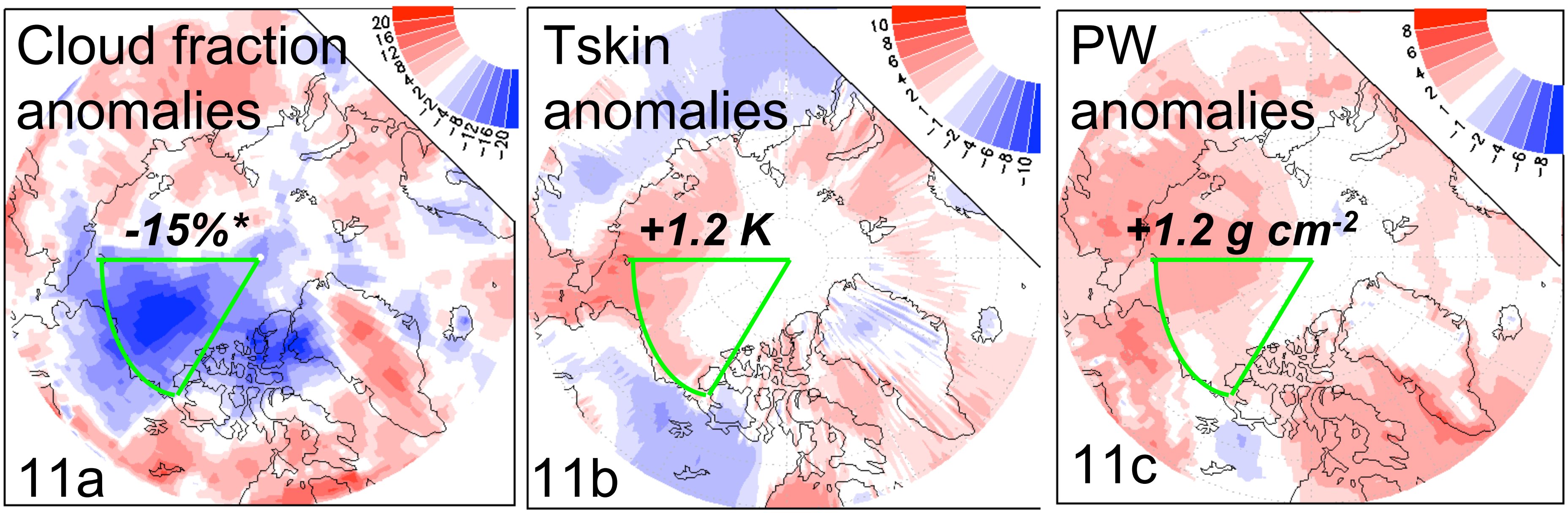
The 2007 ice coverage minima is a noted anomaly. Here, we contrast the summer seasonal mean that of the fluxes that preceded this ice coverage minima in terms of the difference between FLASHFlux 2007 JJA fluxes with the CERES SRBAVG 5-year averages as shown in Figures 8, 9 and 10. The anomaly is simply 2007 minus the 2000-2004 JJA mean.

Figure 11a-c gives anomalies in the cloud and meteorological parameters. Note that large decrease in cloudiness and warmer skin temperatures in a large area poleward of Alaska.

Figure 12 gives the anomalies in the TOA flux fields for SW, SW albedo, LW and Total Net fluxes.

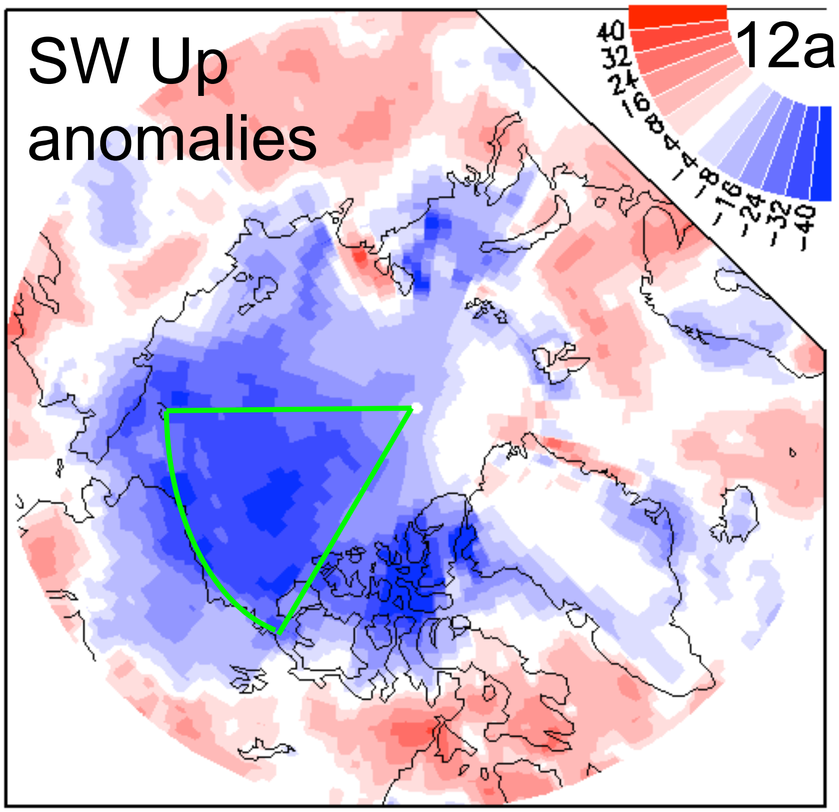
Figure 13 gives the anomalies in the Surface flux fields for LW down and LW fluxes.

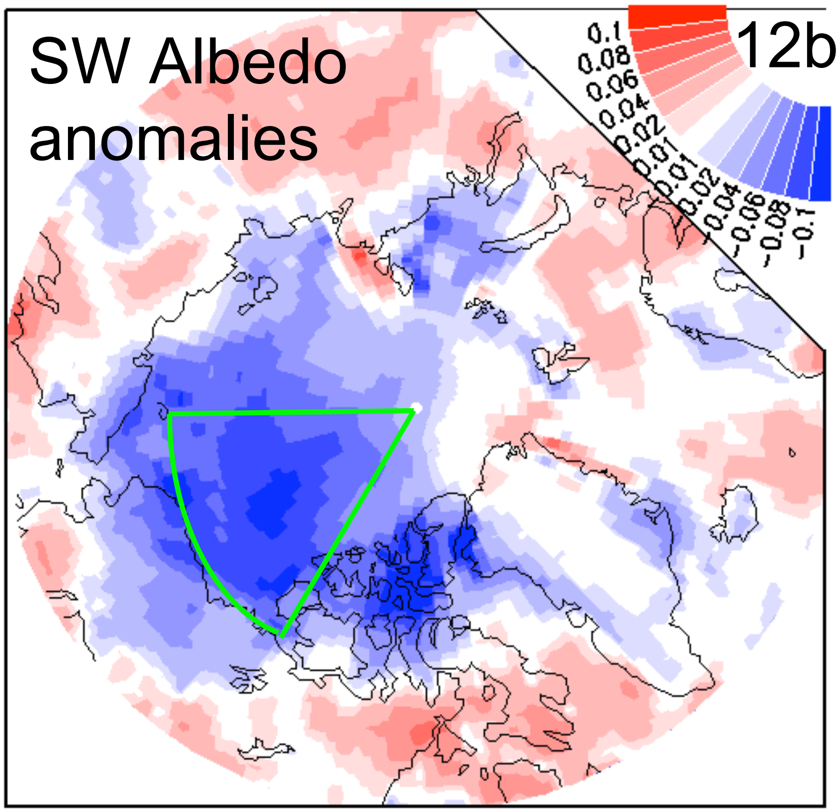
Figure 11a, b, c show anomalies in cloudiness, precipitable water (PW) and Skin Temperature for 2007 JJA Mean minus JJA Mean from 2000-2004. Note area of large change highlighted.



* % is absolute cloud coverage

Figure 12a, b, c, and d shows TOA anomalies in SW up, SW albedo, LW up and Total Net for 2007 JJA Mean minus JJA Mean from 2000-2004.





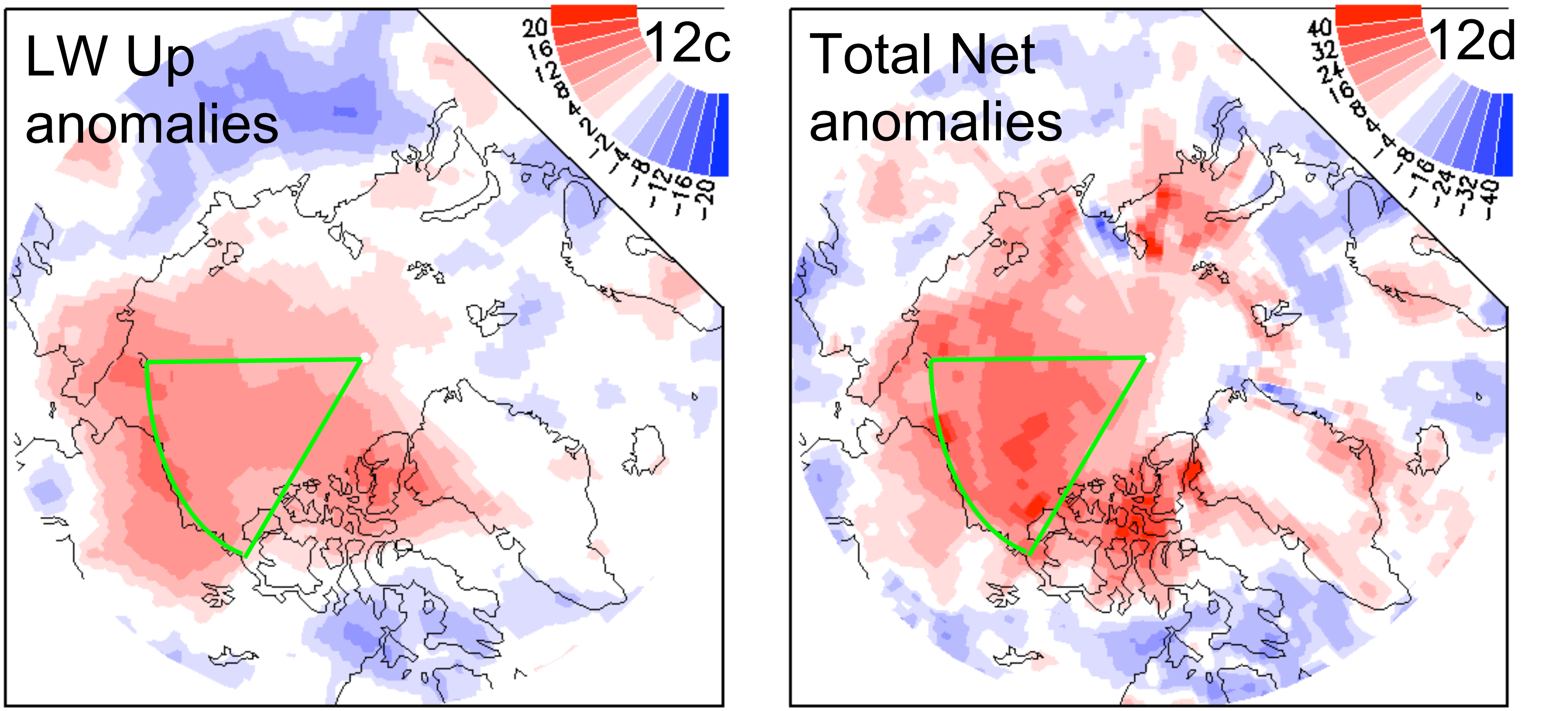
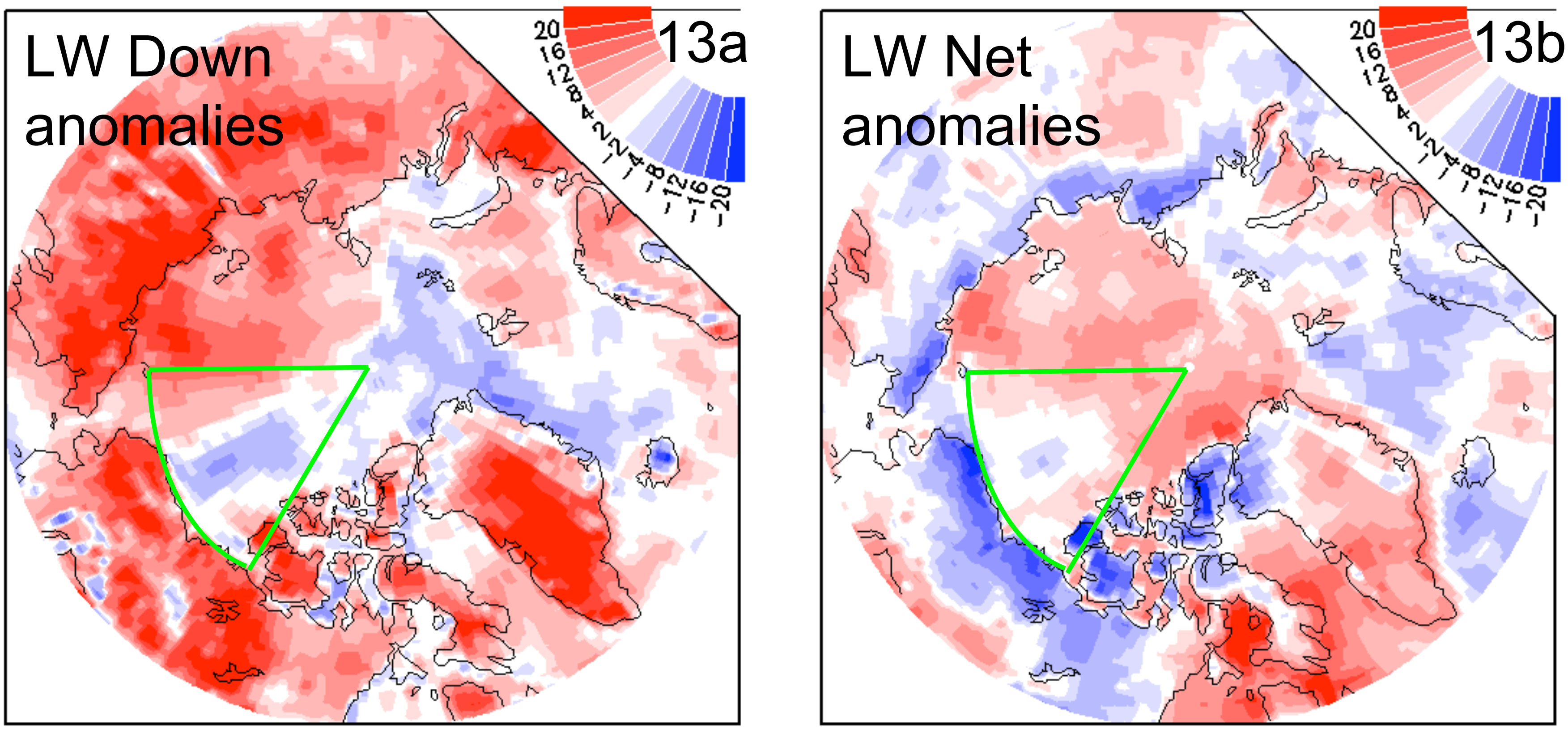

LW Up anomalies
12c
20
16
12
8
4
2
-2
-4
-8
-12
-16
-20
Total Net anomalies
12d
40
32
24
16
8
4
-4
-8
-16
-24
-32
-40

Figure 13a and b show anomalies in the surface LW down and LW Net for 2007 JJA minus JJA Mean from 2000-2004.



VI. Evaluating 2008 Anomalies

The reduction of ice cover in 2008 was significantly less than that of 2007 but still more than the 2000-2004. We also observe a shifting of the ice Eastward. This results in different anomaly patterns than observed in 2007. However, the anomalies are still large relative to the 5-year mean. Here we compute the anomalies relative between 2008 and the 2000-2004 mean.

- Figure 14a-c gives anomalies in the cloud and meteorological parameters.
- Figure 15a-d gives the anomalies in the TOA flux fields for SW, SW albedo, LW and Total Net fluxes.
- Figure 16a-b gives the anomalies in the Surface flux fields for LW down and LW fluxes.

Figure 14a, b, c show anomalies in cloudiness, precipitable water (PW) and Skin Temperature for 2008 JJA Mean minus JJA Mean from 2000-2004. Note area of large change highlighted.

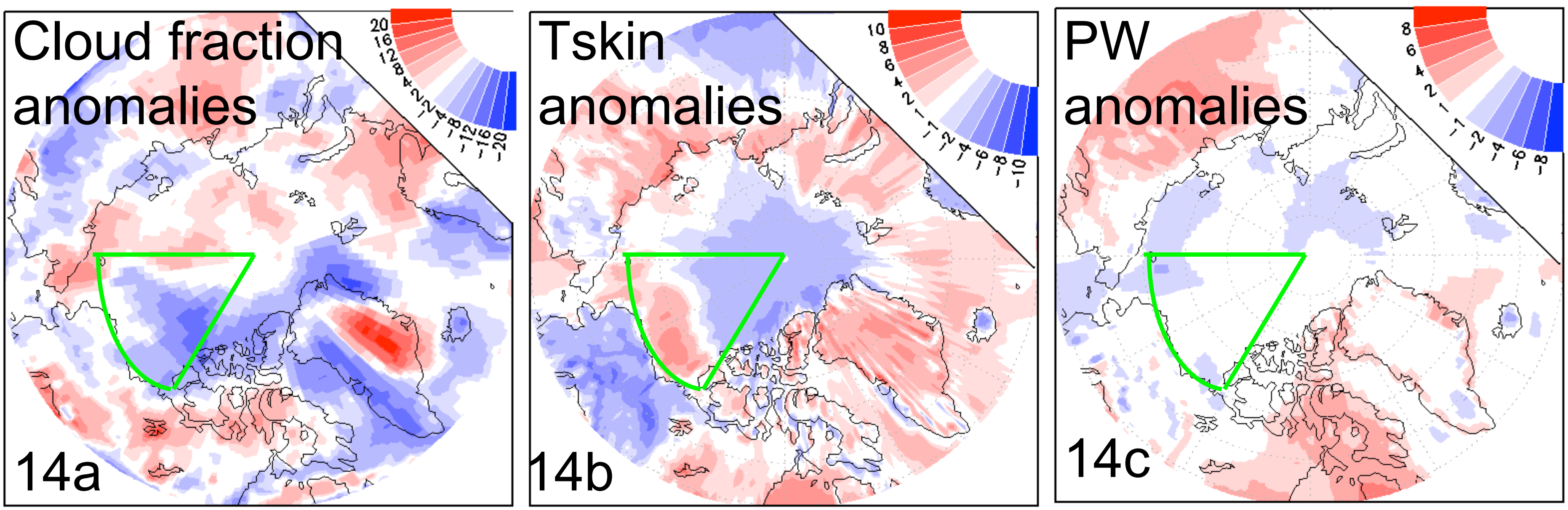
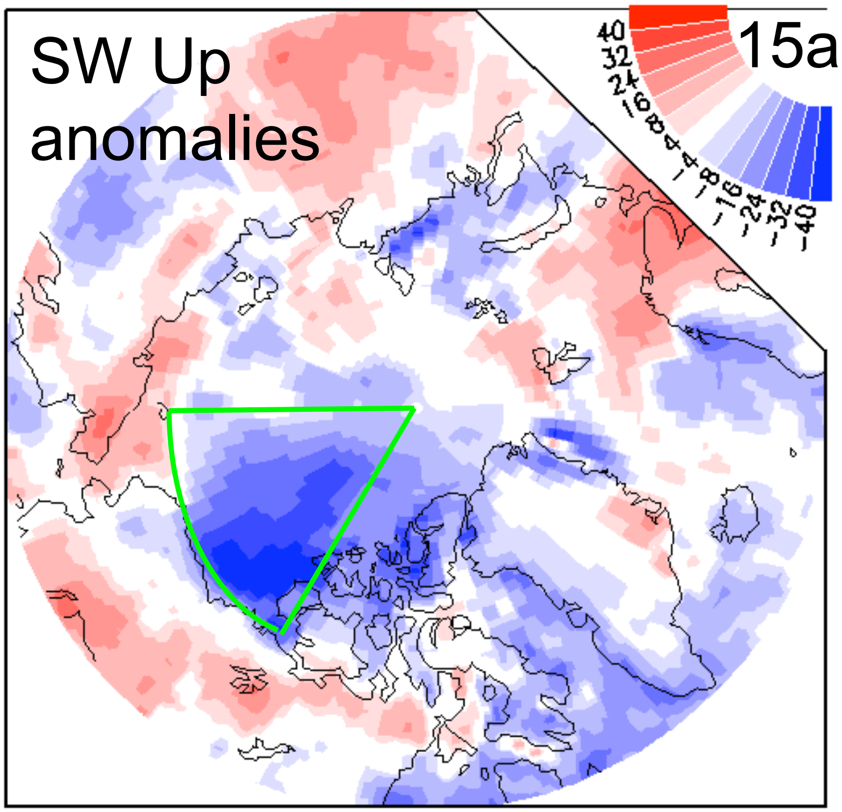
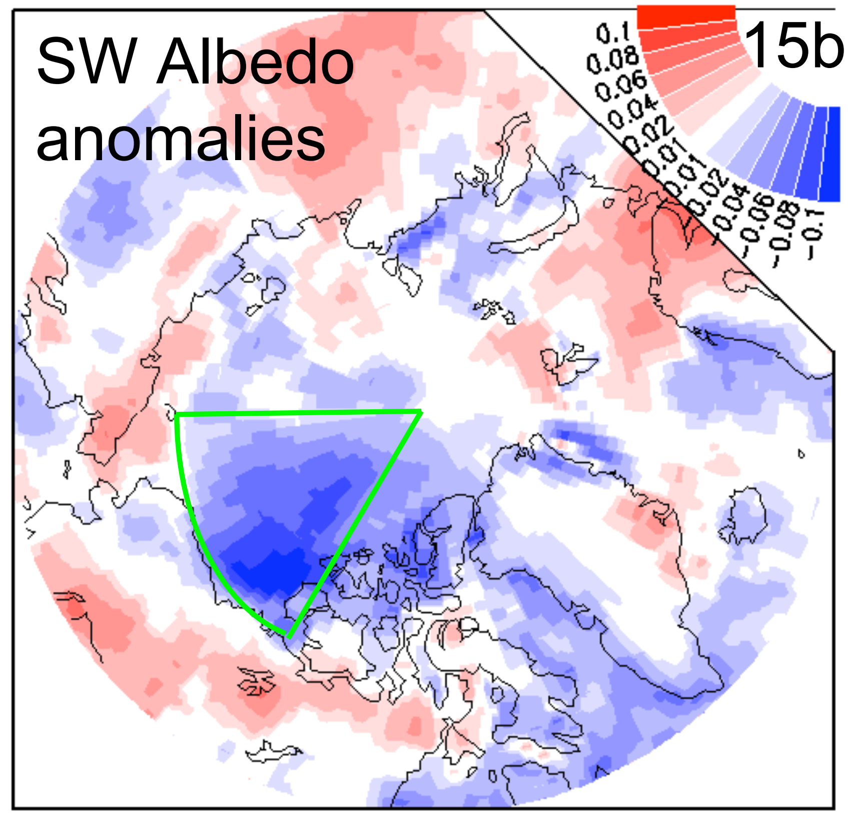
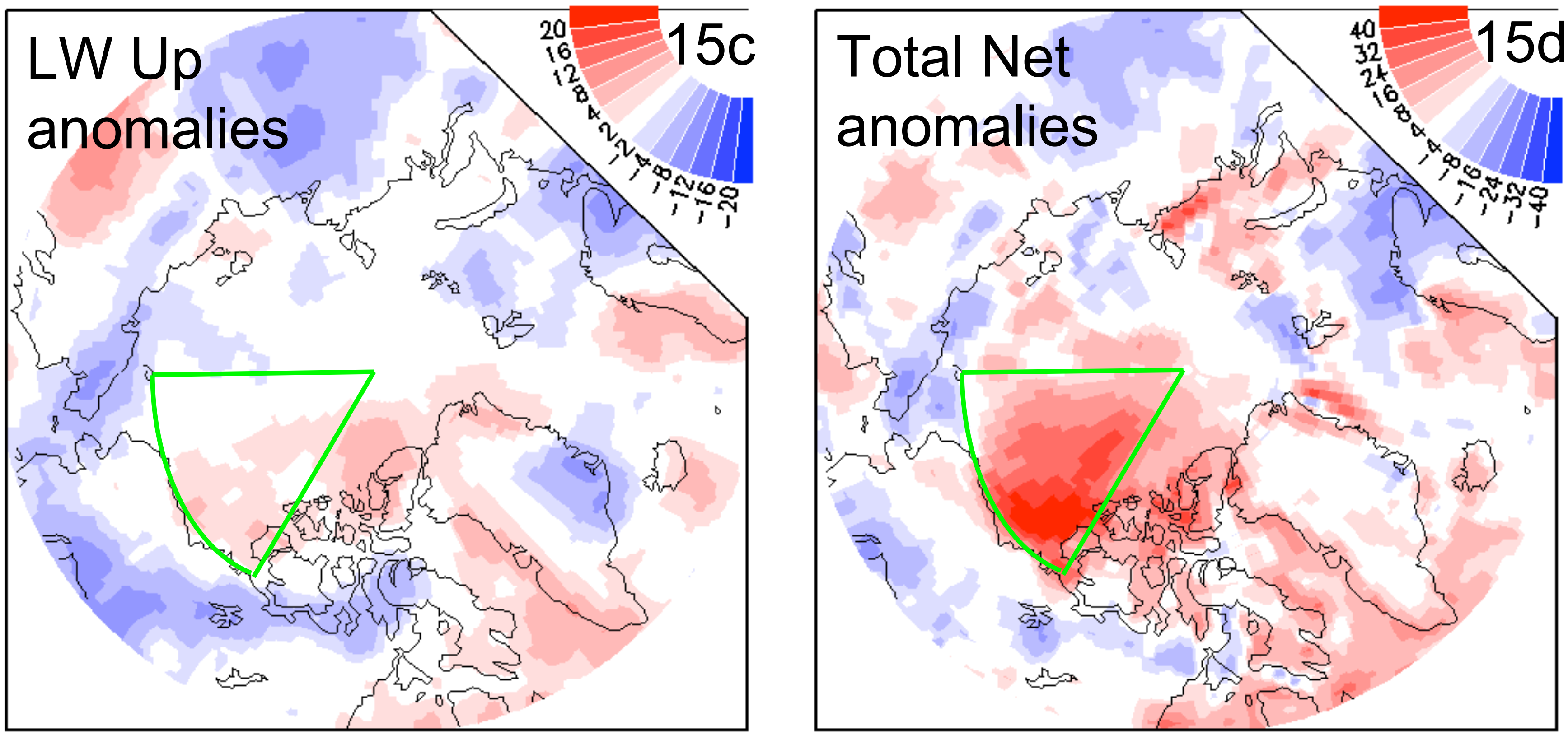


Figure 15a, b, c, and d shows TOA anomalies in SW up, SW albedo, LW up and Total Net for 2008 JJA Mean minus JJA Mean from 2000-2004.

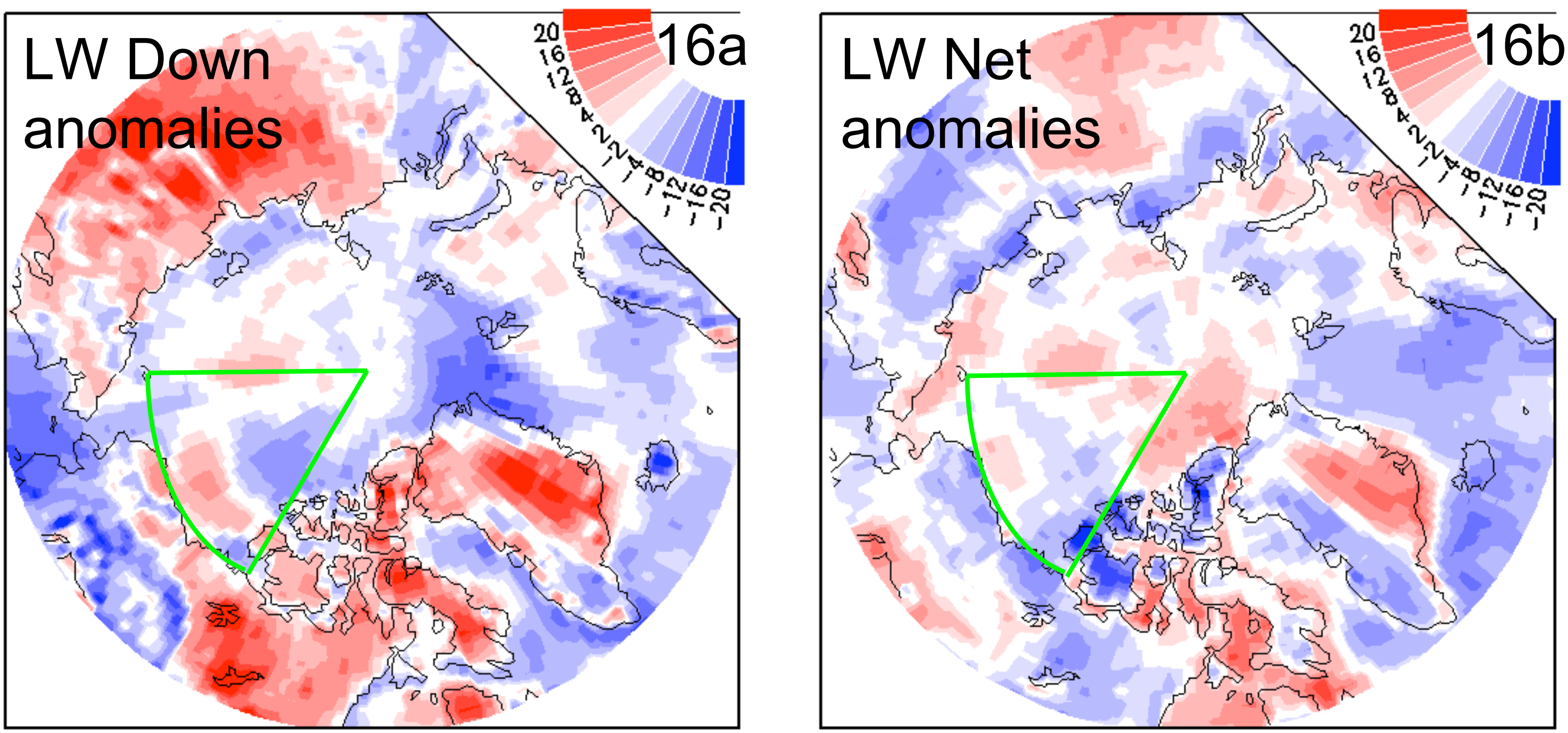






LW Up anomalies
15c
20
16
12
8
4
2
-2
-4
-8
-12
-16
-20
Total Net anomalies
15d
40
32
24
16
8
4
-4
-8
-16
-24
-32
-40

Figure 16a and b show anomalies in the surface LW down and LW Net for 2007 JJA minus JJA Mean from 2000-2004.



VII. Evaluating 2007 verses 2008

In this section we compare 2007 to 2008 directly for the same fields to evaluate these differences.

- Figure 17a-c gives anomalies in the cloud and meteorological parameters.
- Figure 18a-d gives the anomalies in the TOA flux fields for SW, SW albedo, LW and Total Net fluxes.
- Figure 19a-b gives the anomalies in the Surface flux fields for LW down and LW fluxes.

Figure 17a, b, c show anomalies in cloudiness, precipitable water (PW) and Skin Temperature for 2008 JJA Mean minus 2007 JJA Mean.

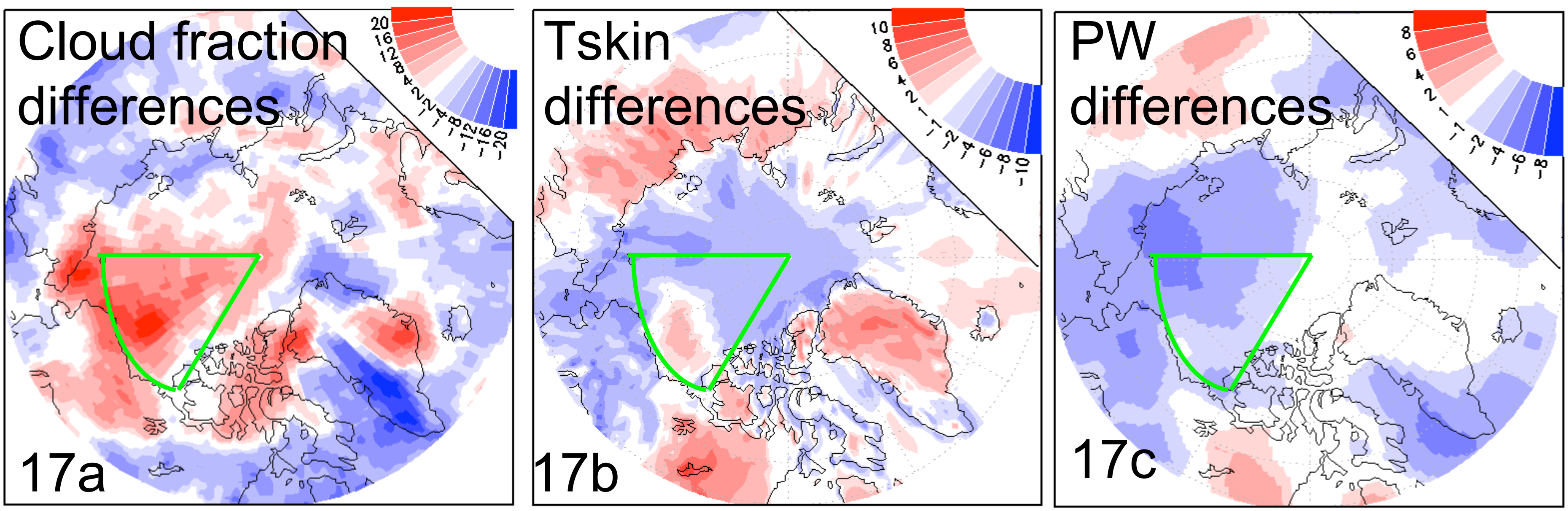
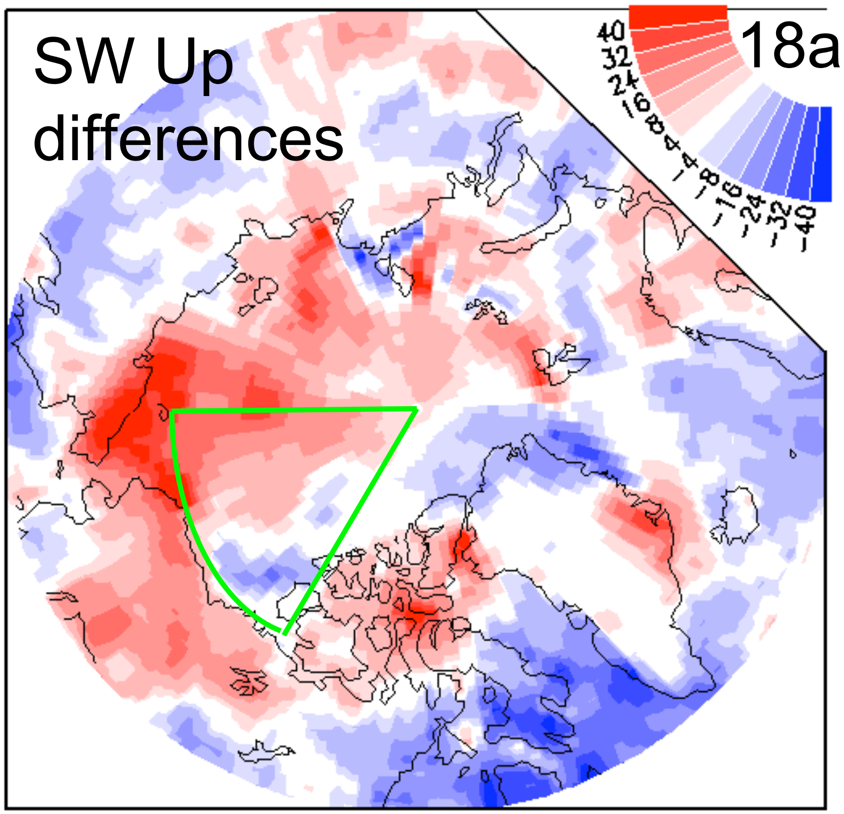
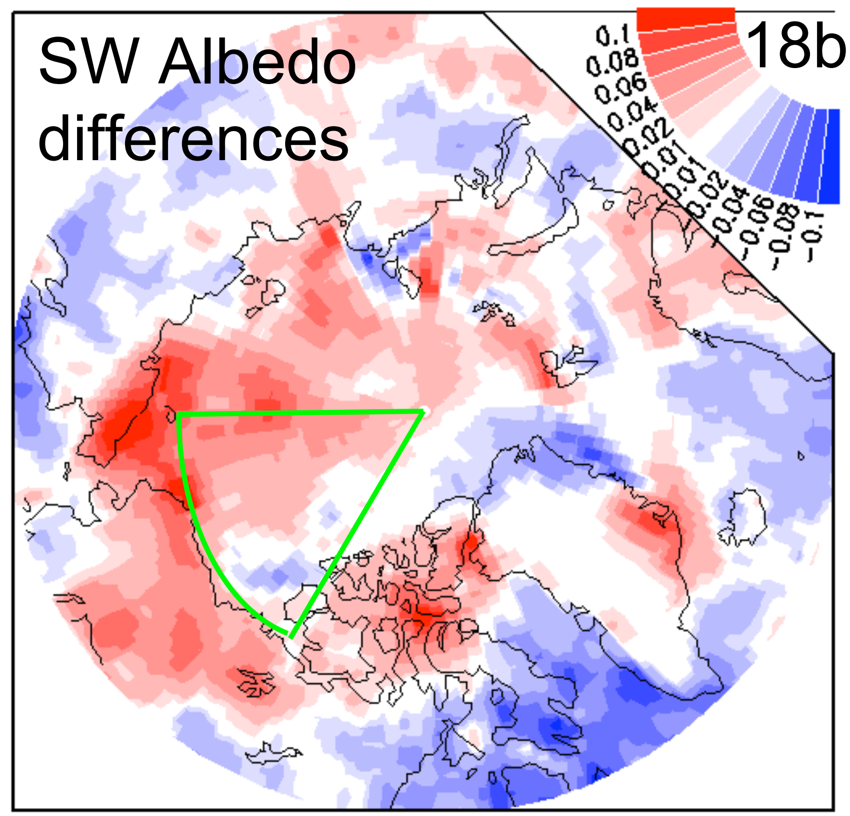
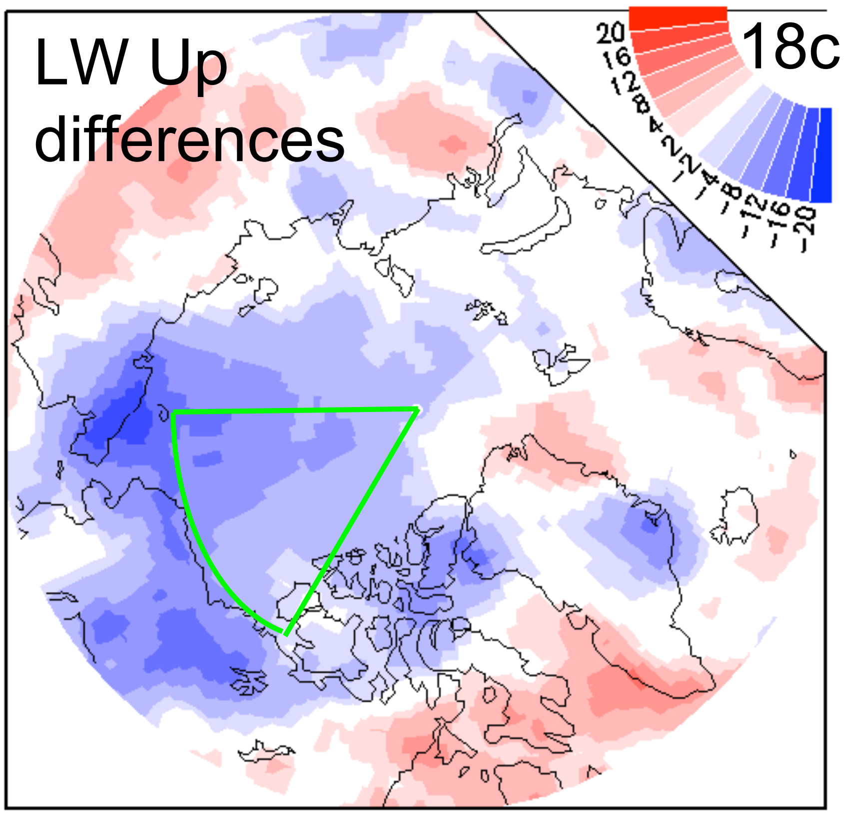


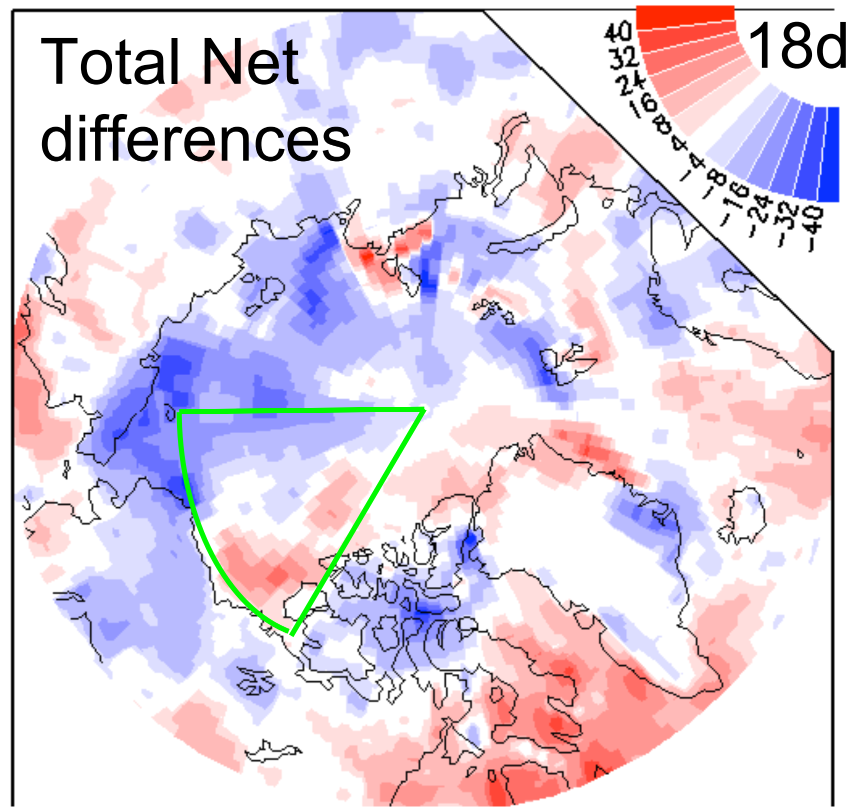
Figure 18a, b, c, and d shows TOA anomalies in SW up, SW albedo, LW up and Total Net for 2008 JJA Mean minus 2007 JJA Mean.





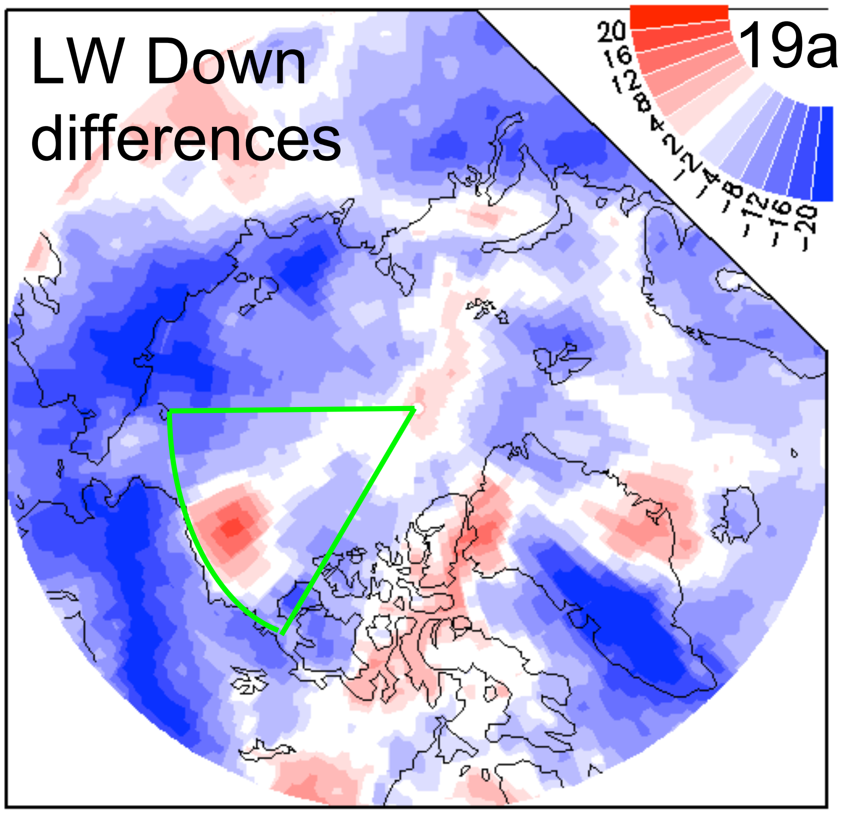


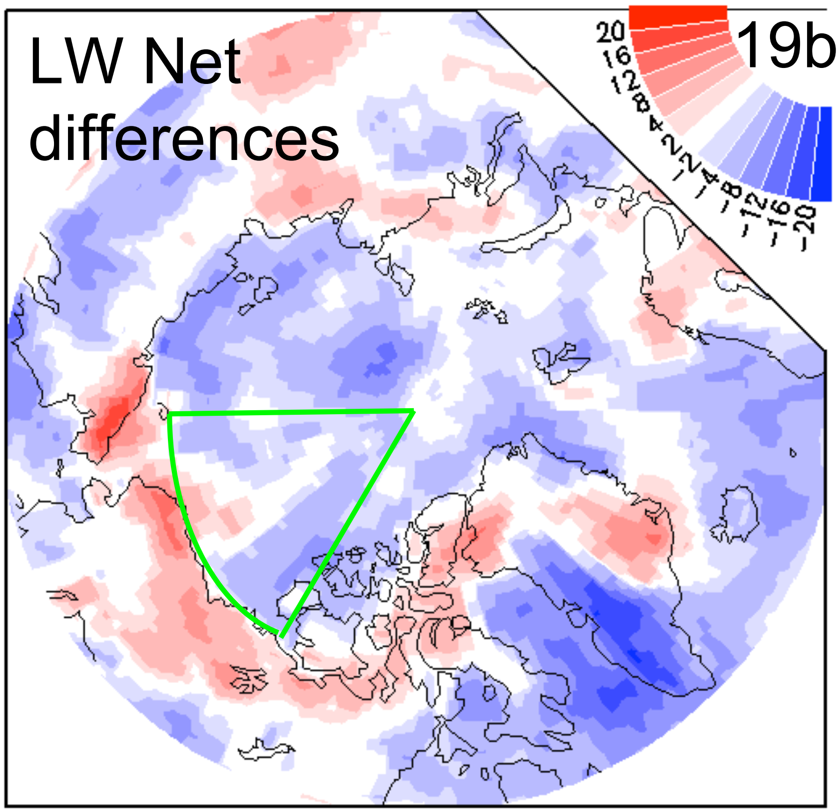
LW Up differences
18c
20
16
12
8
4
2
-2
-4
-8
-12
-16
-20



Total Net differences
18d
40
32
24
16
8
4
-4
-8
-16
-24
-32
-40

Figure 19a and b show anomalies in the surface LW down and LW Net for 2008 JJA minus 2007 JJA Mean.



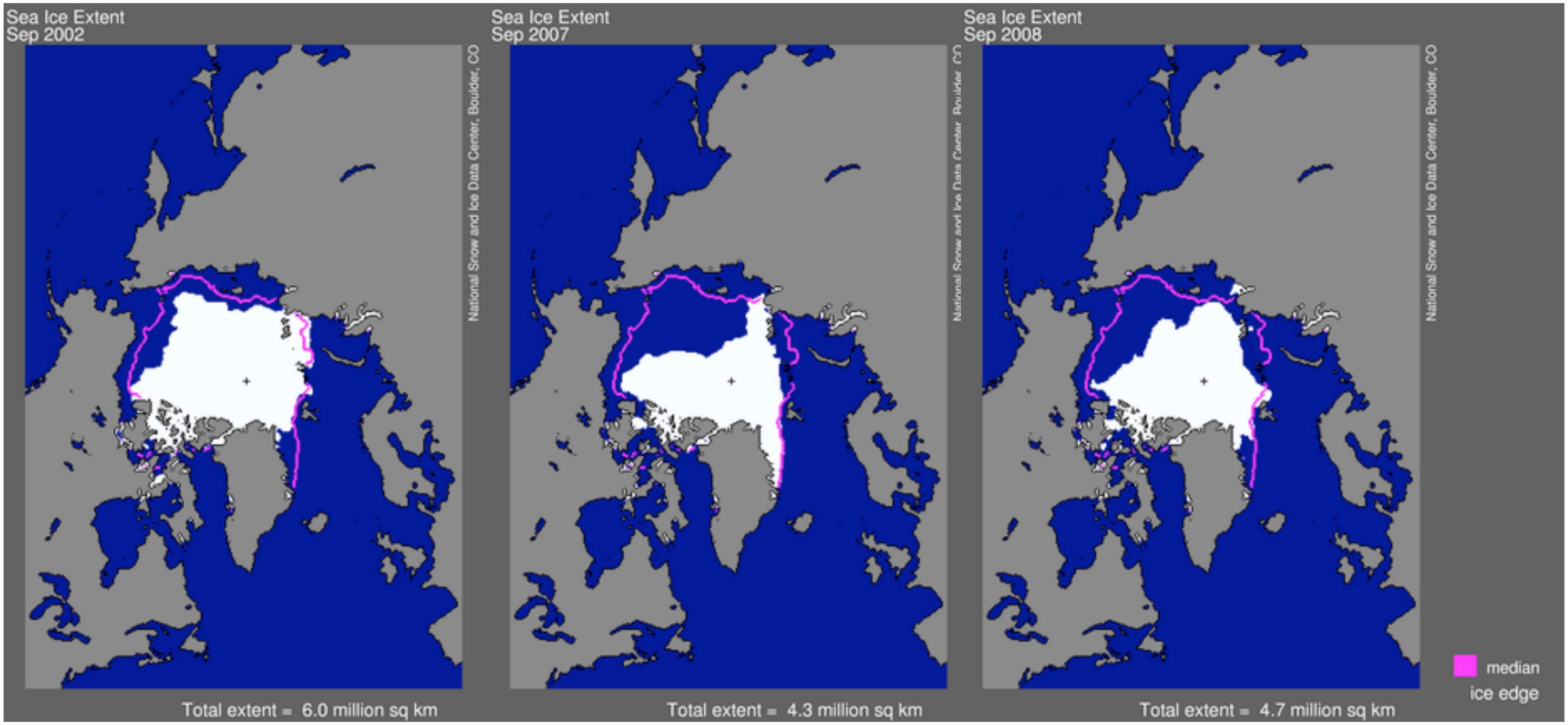


VIII. Discussion and Summary

FLASHFlux differences in radiative fluxes show large variability in the Arctic region radiative properties relative to each other and to the 2000-2004 period. Figure 20 compares the differences in ice coverage for September 2002, 2007 and 2008. Here we use 2002 as a proxy for the 2000-2004 time period. We note that both 2007 and 2008 are far different and have significantly less ice than 2002. However, 2008 has slightly more ice extent than 2007 and this coverage has rotated "eastward" in 2008 relative to 2007. Note in 2008 the lack of ice east of Greenland. These sorts of differences are evident in the radiation fields preceding these distributions.

Figure 20: Ice extent for Sep. 2002, 2007 and 2008 from National Snow Ice Data Center

The summer 2002 lead to an annual ice minimum in September that roughly represents the 2000-2004 period.



To put the differences in perspective, we examine the differences between the 2000-2004, 2007, and 2008 JJA means for the area sector poleward of 70^o and spanning from 120^{o}W to 180^{o}W. The table gives the sector average quantities and the differences in the fields area weighted means for the time periods here.

	SRBAVG	2007	2007 - SRBAVG	2008	2008 - SRBAVG	2008 - 2007
LW TOA (W m^{-2})	221.9	231.3	9.4	223.7	1.8	-7.6
SW TOA (W m-2)	217.4	183.3	-34.1	189.9	-27.5	6.6
TOTAL TOA (W m^{-2})	-13	12.4	25.4	11.3	24.3	-1.1
TOA ALBEDO (W m^{-2})	0.509	0.425	-0.084	0.447	-0.062	0.022
LW DN SURF (W m^{-2})	289.3	289.7	0.4	287.7	-1.6	-2
LW NET SURF (W m^{-2})	-29	-28.2	0.8	-30.7	-1.7	-2.5
Ts (K)	273.6	274.8	1.2	273.7	0.1	-1.1
PW (g cm^{-2})	12.38	13.93	1.55	11.85	-0.53	-2.08
Clouds (%)	78.6	63.6	-15	73	-5.6	9.4

The sector means show that the TOA net radiative flux shows about the same increase for 2007 as 2008 relative to the 2000-2004 mean (about 25 W m^{-2}) for the JJA mean. *This large increase in energy changed the sign of TOA net flux from cooling in 2000-2004 to heating in 2007 and 2008 during the JJA periods.* The 2007 changes are very comparable to the analysis of Kay *et al.,* 2007.

Comparison of 2007 and 2008 shows that 2008 was cooler and had more cloudiness than 2007 in the sector. This accounts for the much more consistent LW TOA fluxes between 2008 and 2000-2004. The surface LW fluxes are very sensitive to the near-surface and skin temperatures as observed by GEOS. Product differences between the 2 versions are being evaluated, but it is evident that 2008 is cooler, than even the 2000-2004 period. Thus, the changes in cloudiness and ice coverage dominate the TOA net radiative flux change.

IX. Acknowledgments

We gratefully acknowledge the support from NASA's Earth Science Applications program and the CERES Mission program and Science team for their support and collaboration for this work. Specifically, we site David Rutan who processed and provided SURFRAD measurements from the CERES Validation Experiment (CAVE). We also acknowledge the Atmospheric Science Data Center for their efforts to process and archive the FLASHFlux data sets.

X. References

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